FEDERAL AID IN FISH RESTORATION
STUDY G-III-D

LAKE AND STREAM INVESTIGATIONS UPPER COOK INLET

Robert Chlupach

F-9-8
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ALASKA DEPARTMENT OF FISH AND GAME
James W. Brooks, Commissioner
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Volume 17 Study G-III-D

STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

LAKE AND STREAM INVESTIGATIONS
POPULATION STUDIES IN UPPER COOK INLET

by

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ALASKA DEPARTMENT OF FISH AND GAME
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RESEARCH PROJECT SEGMENT

State:	ALASKA	Name:	Sport Fish Investigations of Alaska
Project No.:	F-9-8		
Study No.:	G-III	Study Title:	LAKE AND STREAM INVESTIGATIONS
Job No.:	G-III-D	Job Title:	Population Studies of Game Fish and Evaluation of Managed Lakes in the Upper Cook Inlet Drainage.

Period Covered: July 1, 1975 to June 30, 1976.

ABSTRACT

Results of a limnological study of three lakes are presented and water chemistry data are included.

Both the plankton index and periphyton biomass indicate significant correlation to the morphoedaphic index and that the plankton index and periphyton biomass may be used as indicators of relative biological productivity.

Plankton abundance and species composition are discussed for three study lakes.

Effect of rotenone treatment on plankton and benthos of Johnson and Memory lakes is discussed.

A lake stocking study evaluates survival and growth of Winthrop-Ennis strains of rainbow trout, *Salmo gairdneri* Richardson, in two study lakes.

The British Columbia stocking curve is evaluated for Winthrop-Ennis rainbow trout strains in Marion and Christiansen lakes.

Length-weight relationships indicate no significant difference in size of Winthrop-Ennis trout strains.

Naknek rainbow trout success in a lake infested with threespine stickleback, *Gasterosteus aculeatus* (Linnaeus), is evaluated. Lake stocking studies evaluate relative survival and growth of marked and unmarked trout strains of Talarik Creek and Swanson River origin.

BACKGROUND

The nutrient medium is the widely accepted predominant influence of productivity in rearing of fish. Many studies have come forth with the purpose of defining physical or biological variables which can be used to discuss productivity.

A limnological sampling program was initiated in June, 1973 to define selected variables in 10 study lakes (Kalb, 1974). This same program continued through the 1974 field season with no change in sampling design other than (a) exclusion of two lakes, Meirs and Harriet, and (b) samples were taken biweekly. With the advent of the 1975 field season the sampling design was altered to exclude seven lakes from limnological sampling; however, the scope of the project was broadened with initial collection and analysis of periphyton samples.

Lake stocking studies were initiated in 1974 to provide information for the development of a standard stocking procedure in lakes of varying limnological characteristics. Kalb (1974) gives a complete discussion of project design.

RECOMMENDATIONS

1. Determine survival, growth, and total yield of fry and fingerling plants of Winthrop, Washington and Ennis, Montana strains of rainbow trout *Salmo gairdneri*, in Irene Lake.

2. Determine survival, growth, and total yield of Ennis strain trout in Johnson Lake.

3. Continue evaluation of survival and growth of marked and unmarked Swanson-Talarik rainbow trout strains in Reed and Long lakes.

4. Discontinue evaluation of environmental effects of rotenone treatment on Memory Lake.

5. Limnological sampling should continue on Matanuska-Susitna Valley lakes to provide representative data of lake productivity.

6. Evaluate survival and growth of Swanson and Talarik rainbow trout strains in Big No Luck, Little No Luck, and Canoe lakes.

OBJECTIVES

1. To determine survival, growth, and total yield of stocked game fishes in landlocked lakes of the area.

2. To determine the effect of rotenone treatment on food organisms utilized by game fishes in lakes of the area.

3. To determine limnological conditions which reflect the productivity of study lakes of the area.

4. To provide recommendation for the management of stocked lakes and to direct the course of future studies.

TECHNIQUES USED

Plankton samples were collected biweekly from Memory, Johnson, and Matanuska lakes. Collection, preservation, and centrifuge procedures are described by Kalb (1975). For species identification purposes a vertical plankton haul from the bottom was collected and preserved from each lake.

Zooplankton from Memory, Johnson, and Matanuska lakes were identified by species, and the individual number of each species was determined. Percentage abundance for the sample date was calculated from a series of three aliquots for each plankton sample.

Techniques for biweekly collection of bottom organisms from Memory and Johnson lakes are described by Kalb (1975), as are techniques for preservation and identification of organisms.

U. S. Geological Survey techniques for collection and analysis of periphyton samples (Slack, et al., 1973) were used. A Mettler H-10 balance was used in weighing samples.

Fish populations were sampled using 125 x 6-ft. variable mesh monofilament gill nets composed of five different mesh panels ranging from 1/2 to 2-inch bar measure. Nets were fished for a minimum of 24 hours.

All fish measurements were expressed in fork lengths to the nearest millimeter and in weight to the nearest gram.

Lakes receiving fish plants of a certain strain or matching plants for population estimates were anesthetized, hand counted, and marked by hand-clipping the right or left ventral fin and/or removal of adipose fin. A detailed description for selection of fish for matching plants in making population estimates is presented by Kalb (1973). Delayed sampling of matching plants in determination of population size is also described in detail by Kalb (1974).

Water samples were collected with a Kemmerer water bottle, and dissolved oxygen levels determined by PAO titration. Alkalinity, hardness and pH were determined with the Hach AL-36-WR Field Test Kit.

Water temperature and conductivity were measured with a YSI Tele-thermometer and a Hach Model 2510 conductivity meter, respectively.

FINDINGS

Water Chemistry:

Water chemistry determinations were made biweekly for Memory, Johnson, and Matanuska lakes (Table 1). Dissolved oxygen and temperature profiles were recorded in conjunction with each biweekly plankton sampling data.

Dissolved oxygen and temperature determinations did not represent typical conditions for spring turnover in Matanuska and Johnson lakes during 1975 (Table 2). Both lakes were ice free on May 15 and data recording began on May 19. Fall turnover in both lakes occurred the last week of October. Memory Lake followed the pattern of spring overturn, summer stabilization and fall overturn on the approximate dates of May 19, July 14, and October 13, respectively.

Plankton:

An indicator of biological productivity is the measurement of plankton abundance and species composition. Shown in Figure I is the frequency of the mean centrifuge volume obtained from plankton tows during 1975. A summary of that data is given in Table 3. Development of a plankton index relative to lake productivity must take into account the volume of water suitable to plankton production. The lake itself is basically comprised of the trophogenic (photosynthetic production zone) and tropholytic zones (decomposition zone). The trophogenic zone during summer stagnation is an area of high dissolved oxygen concentration since it includes photosynthetic activity and water mixing.

Quantitative comparisons of shallow to deep lakes is complicated because the trophogenic zone in a shallow lake may encompass the entire water column; whereas in a deep lake the epilimnion may fluctuate throughout the summer. The extent of the possible trophogenic zone is often less than total lake volume yet of greater volume than that of a shallow lake.

Kalb (1974) described the trophogenic zone in deeper lakes as the maximum depth of high dissolved oxygen penetration estimated from dissolved oxygen profiles. The depth of dissolved oxygen for each sampling date was divided into the mean plankton centrifuge volume for that same date and multiplied by a factor of 10, resulting in the plankton index for the lake.

Kalb (1975) calculated the plankton index for shallow lakes by dividing the seasonal average centrifuge volume by the depth of the plankton tow, then multiplying by a factor of 10. A summary of plankton indexes for 1973, 1974, and 1975 in the study lakes is presented in Table 3.

The study lakes for the 1974 period were arranged according to their numerical value of plankton index (Kalb, 1975) indicating a ranking of relative productivity. A comparison of plankton values determined in 1975 with those of 1974 shows the study lakes ranked at the same relative productivity levels.

Table 1. Summary of Water Chemistry Characteristics for Three Matanuska Valley Lakes, 1975.

Lake	Sampling Period	pH		Total Alkalinity as $CaCO_3$ (ppm)		Total Hardness as $CaCO_3$ (ppm)		Conductivity (microhmos/cm)	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
Johnson	5/20-10/9/75	8.5	7.7-8.8	95	85-120	82	68- 86	118	113-130
Matanuska	5/21-10/13/75	8.7	7.9-9.0	135	120-171	129	103-171	207	200-220
Memory	5/19-10/13/75	7.7	7.3-8.0	45	34- 51	34	34- 34	43	38- 51

Table 2. Dissolved Oxygen-Temperature Determinations for Three Matanuska Valley Lakes, 1975.

		Johnson		Matanuska		Memory	
Date	Depth (m)	D.O. (ppm)	Temp. (°F)	D.O. (ppm)	Temp. (°F)	D.O. (ppm)	Temp. (°F)
5/19	1	12.0	49.0	10.1	46.0	8.5	47.0
	3	12.0	48.0	9.7	45.0	8.2	45.0
	6	5.2	40.5	8.6	43.5	7.4	43.5
	9	0.7	39.5	4.4	40.0		
	12	0.5	39.5	2.0	39.5		
	15	0.2	39.5	2.2	39.5		
	18			0.7	39.5		
	21			0.4	39.5		
	24			0.3	39.5		
6/5	1	12.2	59.0	12.8	57.0	11.5	56.0
	3	14.9	56.0	14.8	53.0	12.4	55.0
	6	12.8	43.0	9.6	46.0	16.3	50.0
	9	0.4	39.5	3.2	42.0		
	12	0.2	39.5	0.8	40.5		
	15	0.1	39.5	0.8	40.0		
	18			0.9	40.0		
	21			0.8	39.5		
	24			0.5	39.5		
6/16	1	12.3	62.0	11.9	60.0	10.9	62.0
	3	11.3	61.0	12.8	56.0	10.8	56.0
	6	17.5	45.0	11.1	44.0	8.9	52.0
	9	1.4	39.5	1.2	40.0		
	12	0.6	39.5	2.4	39.5		
	15	0.1	39.5	2.6	39.5		
	18			0.5	39.5		
	21			0.4	39.5		
	24			0.2	39.5		
6/30	1	9.7	63.0	11.4	63.0	10.3	63.0
	3	9.8	63.0	11.5	63.0	10.4	63.0
	6	20.9	48.0	18.6	50.0	3.1	54.0
	9	.0.5	39.5	0.7	42.0		
	12	0.5	39.5	0.2	40.5		
	15	4.3	39.5	0.4	40.0		
	18			0.6	39.5		
	21			0.9	39.5		
	24			0.3	39.5		
7/14	1	8.8	67.0	10.7	67.0	9.5	68.0
	3	9.0	67.0	10.8	67.0	9.5	68.0
	6	24.1	52.0	22.3	54.0	0.8	55.0

Table 2. Dissolved Oxygen-Temperature Determinations for Three Matanuska Valley Lakes, 1975. Cont.

Date	Depth (m)	Johnson D.O. (ppm)	Johnson Temp. (°F)	Matanuska D.O. (ppm)	Matanuska Temp. (°F)	Memory D.O. (ppm)	Memory Temp. (°F)
7/14	9	0.3	40.0	0.6	41.0		
	12	0.1	39.5	0.4	39.5		
	15	0.0	39.5	0.2	39.5		
	18			0.3	39.5		
	21			0.1	39.5		
	24			0.0	39.5		
7/30	1	9.3	65.0	11.9	64.0	9.9	65.0
	3	9.1	65.0	11.9	64.0	9.5	64.0
	6	16.7	52.0	18.1	56.0	1.8	54.0
	9	0.2	40.0	1.1	41.0		
	12	0.1	39.5	0.1	40.0		
	15	0.0	39.5	0.1	39.5		
	18			0.1	39.5		
	21			0.0	39.5		
	24			0.0	39.5		
8/12	1	8.7	63.0	11.5	66.5	9.7	64.0
	3	9.3	63.0	11.5	66.0	10.1	64.0
	6	18.1	55.0	16.0	59.0	2.2	58.0
	9	1.1	41.0	11.4	42.0		
	12	0.0	39.5	0.0	40.0		
	15	0.0	39.5	0.0	39.5		
	18			0.0	39.5		
	21			0.0	39.5		
	24			0.0	39.5		
9/3	1	9.4	59.5	11.5	59.5	9.2	58.0
	3	9.5	59.5	11.7	59.5	8.6	55.0
	6	10.4	56.0	11.9	59.5	8.8	53.0
	9	0.4	40.0	13.2	42.0		
	12	0.0	39.5	0.0	39.5		
	15	0.0	39.5	0.0	39.5		
	18			0.0	39.5		
	21			0.0	39.5		
	24			0.0	39.5		
9/12	1	10.4	55.0	11.2	56.0	8.7	53.0
	3	10.3	55.0	10.3	56.0	8.5	52.5
	6	9.5	55.0	9.5	56.0	8.7	52.0
	9	0.6	45.0	11.4	50.0		
	12	0.8	39.5	0.0	41.0		
	15	0.2	39.5	0.0	39.5		

Table 2. Dissolved Oxygen-Temperature Determinations for Three Matanuska Valley Lakes, 1975. Cont.

		Johnson		Matanuska		Memory	
Date	Depth (m)	D.O. (ppm)	Temp. (°F)	D.O. (ppm)	Temp. (°F)	D.O. (ppm)	Temp. (°F)
9/12	18			0.0	39.5		
	21			0.0	39.5		
	24			0.0	39.5		
9/23	1	9.4	51.5	10.1	52.0	10.5	50.5
	3	10.3	51.5	10.0	52.0	10.5	50.5
	6	9.6	51.5	10.5	52.0	10.4	50.0
	9	1.8	45.0	10.4	51.0		
	12	0.5	39.5	0.0	41.0		
	15	0.0	39.5	0.0	40.0		
	18			0.0	39.5		
	21			0.0	39.5		
	24			0.0	39.5		
10/13	1	7.4	46.0	8.0	44.0	9.4	40.5
	3	7.4	46.0	8.1	44.0	9.7	40.5
	6	7.1	46.0	9.1	44.0	9.7	40.5
	9	5.5	45.0	9.1	45.0		
	12	0.1	39.5	7.4	42.0		
	15	0.0	39.5	0.0	39.5		
	18			0.0	39.5		
	21			0.0	39.5		
	24			0.0	39.5		

Table 3. Summary of Plankton Volumes and Indexes for Three Matanuska Valley Lakes, 1975.

	Centrifuge Volume (ml)				PI			
Lake	Depth (m)	Seasonal Range	Seasonal Total	Seasonal Average	1973	1974	1975	MEI
Johnson	5	0.2- 2.8	8.19	0.74	4.89	2.09	1.60	7.4
	11	0.2- 2.9	10.62	0.96				
Matanuska	5	0.5- 5.5	26.99	2.45	16.19	5.46	5.20	8.3
	22	0.5-12.2	42.94	3.90				
Memory	3.5	0.1- 1.1	4.19	0.38	0.86	0.69	1.19	5.6

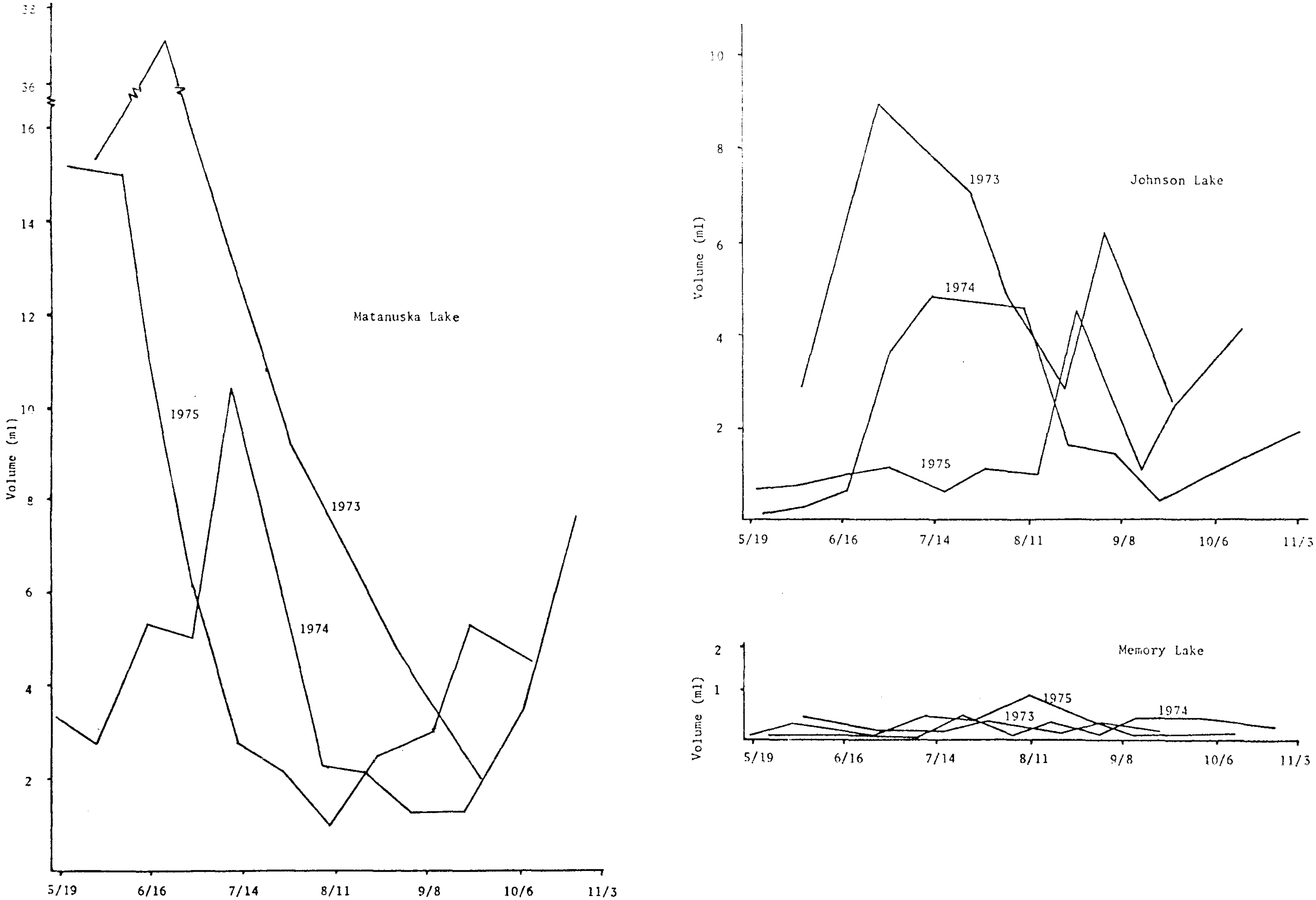

Figure 1. Mean Plankton Volumes in Study Lakes 1973, 1974 and 1975.

Another indicator of biological productivity, the morphoedaphic index (MEI), was used in comparison to the plankton index (PI) to determine PI suitability as an indicator of production. The MEI is derived from a measure of dissolved nutrient concentration and morphometry of a lake and is described by Ryder et. al (1974) as a method for calculating potential productivity in northern temperature lakes.

Kalb (1975) found that for 1973, PI values differed from 1974 values; however, Matanuska, Johnson, and Memory lakes had been chemically rehabilitated in the fall of 1973, possibly accounting for the observed differences in PI values. Although 1973 and 1974 PI values were different, their relationship to the MEI was similar in both years (Kalb, 1975). Figures 2, 3, and 4 depict PI on MEI correlations for study lakes. Table 3 shows PI values in study lakes determined in 1975 are higher than PI values of the previous year, although not equal to values prior to rotenone treatment. Kalb (1975) noted rotenone treatment retarded zooplankton activity; however, present PI values indicate return to higher plankton levels. Comparison of the PI-MEI linear regressions (Kalb, 1975) by analysis of covariance shows no significant difference between the slopes for 1973 and 1974; however, slope of 1975 PI-MEI linear regression indicated a slight significant difference between slopes determined for 1973 and 1974. These variances, though slight, may in part be caused by the number of lakes for which PI values were determined, i.e., three in 1975 and 10 in both 1973 and 1974.

On each sampling date an additional plankton haul was made from the maximum lake depth for purposes of zooplankton species identification (Kalb, 1975). A list of species and size compositions are recorded in Table 4 and Figure 5, respectively. The geometric shapes in Figure 5 illustrate seasonal succession of zooplankton and the catch composition by percent species abundance for each sample date.

Assessment of Rehabilitation:

The present practice of chemically treating lakes just before formation of winter ice cover is known to significantly reduce the deterioration rate of rotenone. Since this prolonged toxicity is believed to hinder reestablishment of invertebrate organisms in the productive season following rehabilitation, a study was initiated to determine the extent of effects of rotenone on those organisms (Kalb, 1975).

Johnson and Memory lakes were chemically treated in September, 1973 with concentrations of 0.6 ppm and 0.8 ppm Pro-Noxfish, respectively, to remove threespine stickleback, Gasterosteus aculeatus, (Linneaus) populations. Duration of rotenone toxicity in the two lakes was determined using live fish suspended in cages, and the chemical test for rotenone described by Post in Kalb (1975) was made. By February 26, 1974, the concentration in Johnson Lake had dropped to approximately 0.2 ppm as determined by the chemical method (Kalb, 1975). Kalb (1975) suspended chinook salmon fingerling, Oncorhynchus tshawytscha (Walbaum), in cages at 10-foot intervals from the surface to the bottom on April 1, 1974. After four days all fish were still alive, indicating detoxification had occurred (Kalb, 1975).

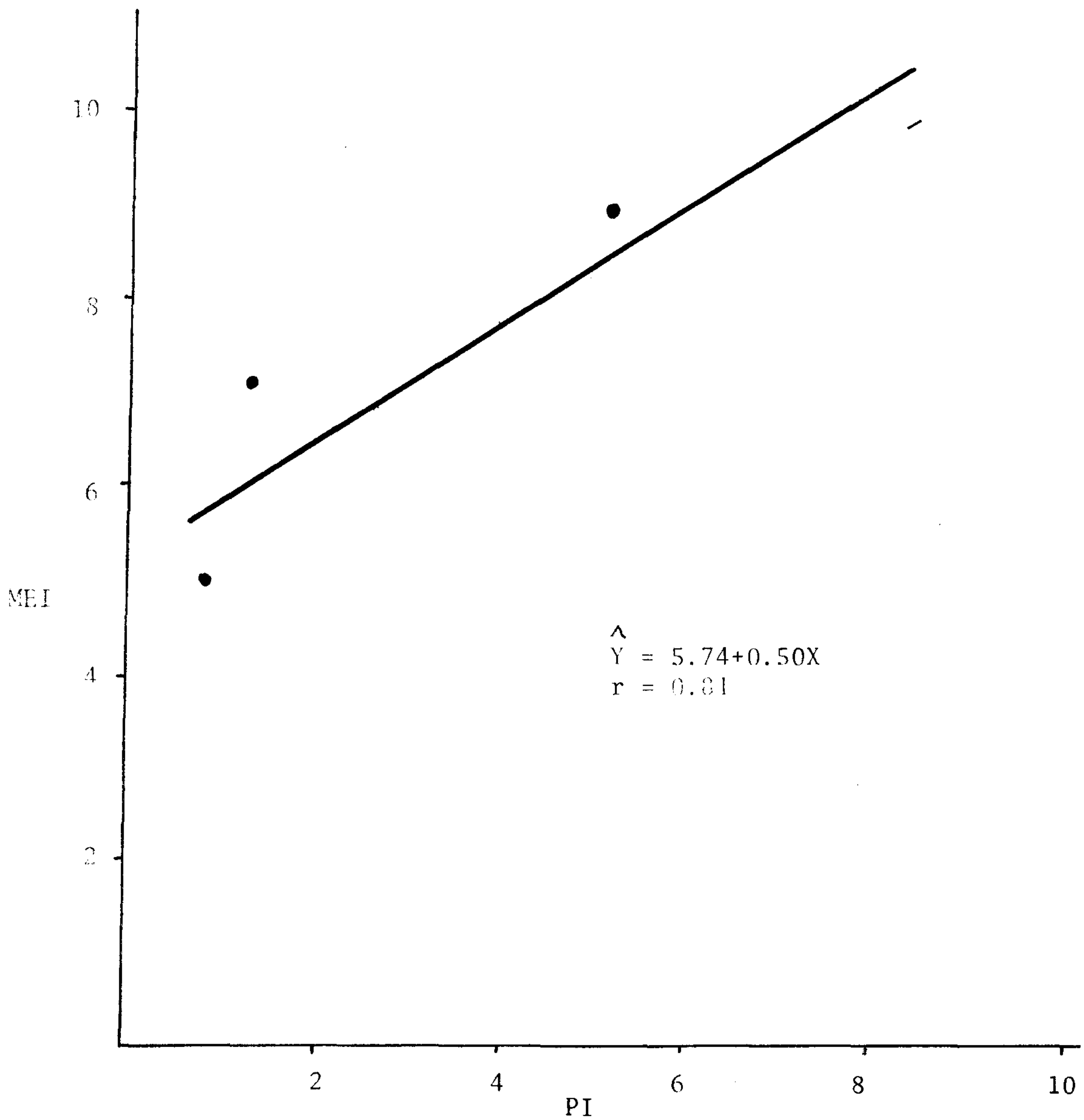

Figure 2. Linear Regression of Morphoedaphic Index (MEI) on Plankton Index (PI), 1975.

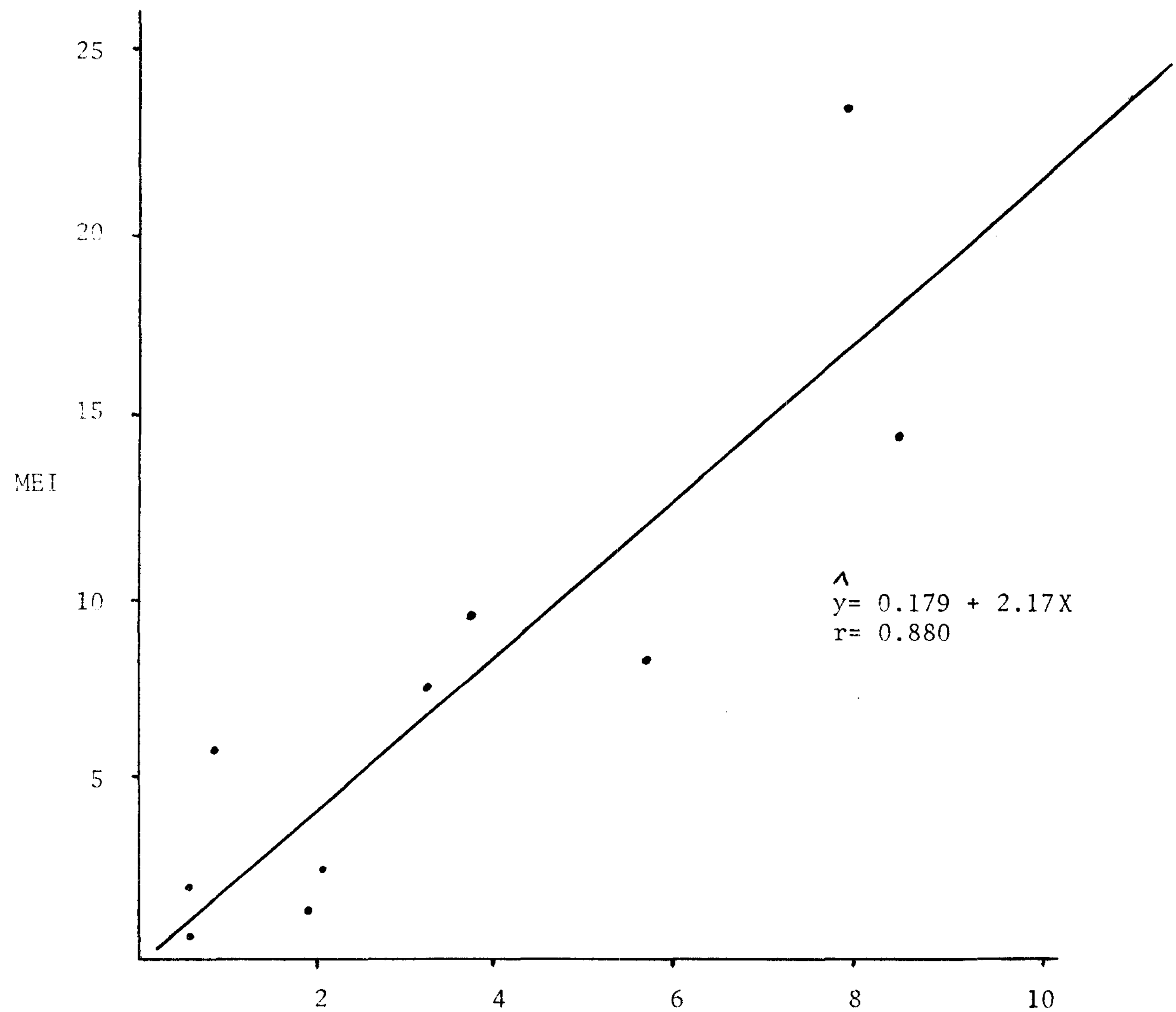

Figure 3. Linear Regression of Morphoedaphic Index (MEI) on Plankton Index (PI), 1974

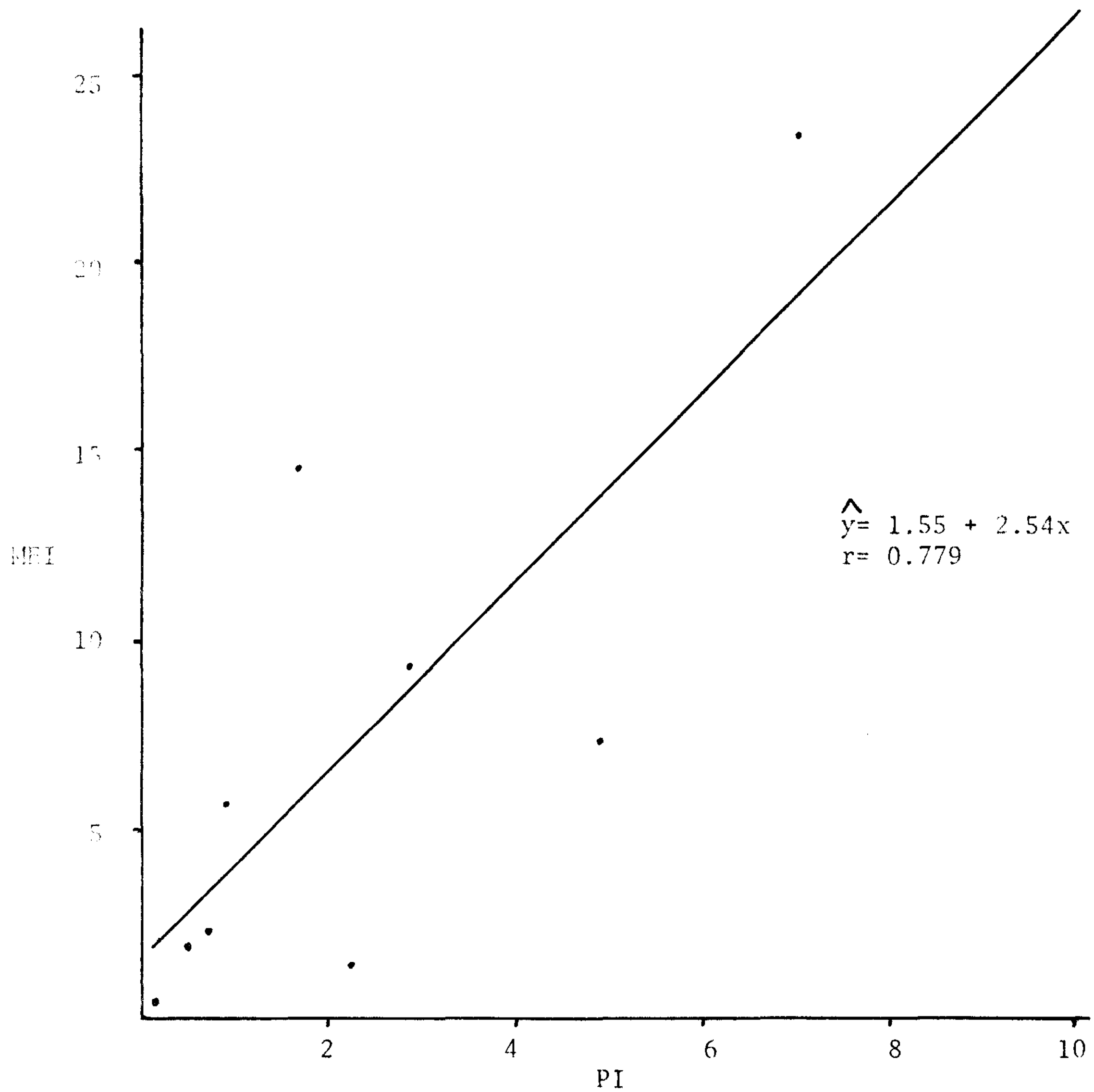

Figure 4. Linear Regression of Morphoedaphic Index (MEI) on Plankton Index (PI), 1973.

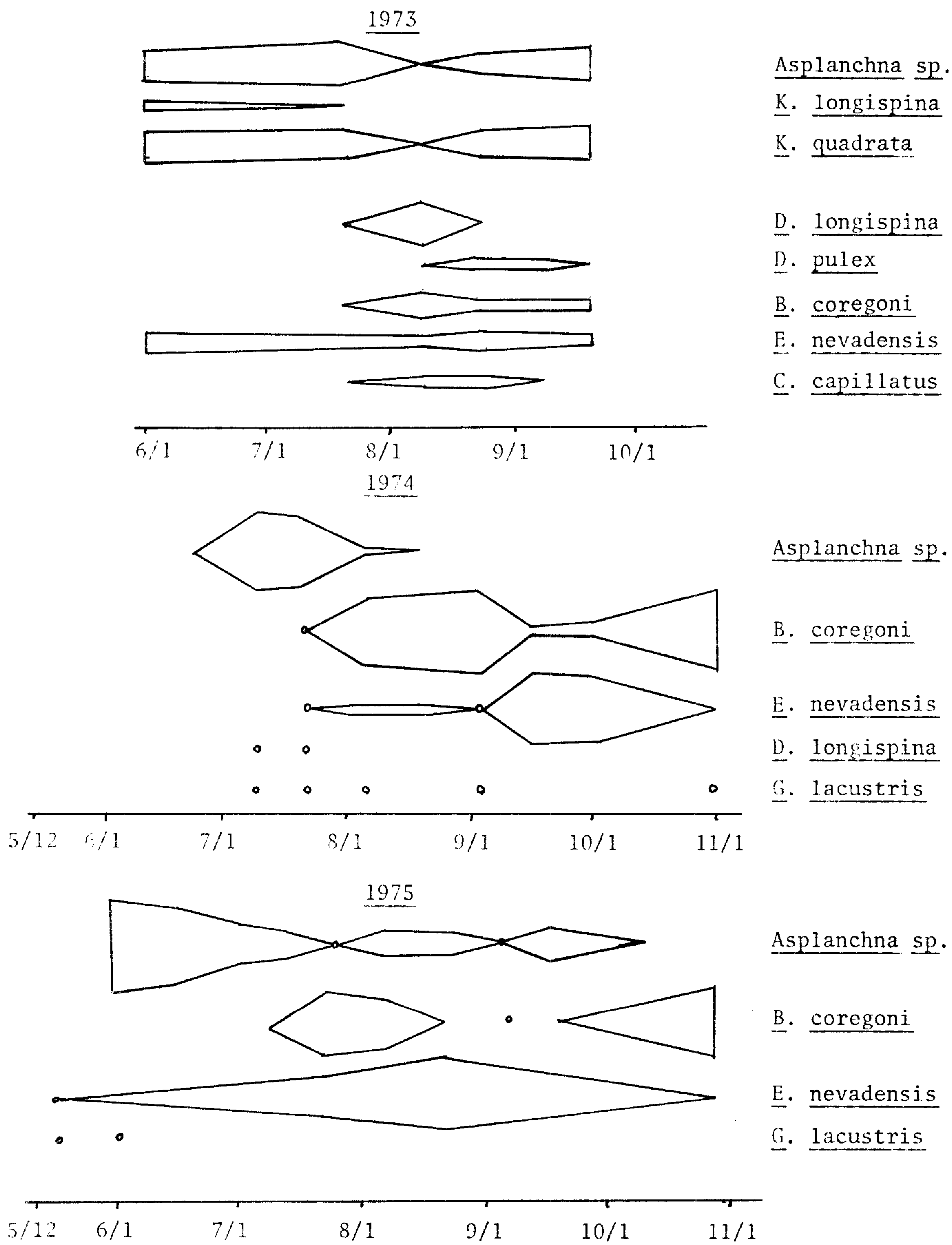

Figure 5. Relative Width of Geometric Figures is the Approximate Relative Species Composition of the Plankton Community by Numbers on Sampling Dates.

Memory Lake.

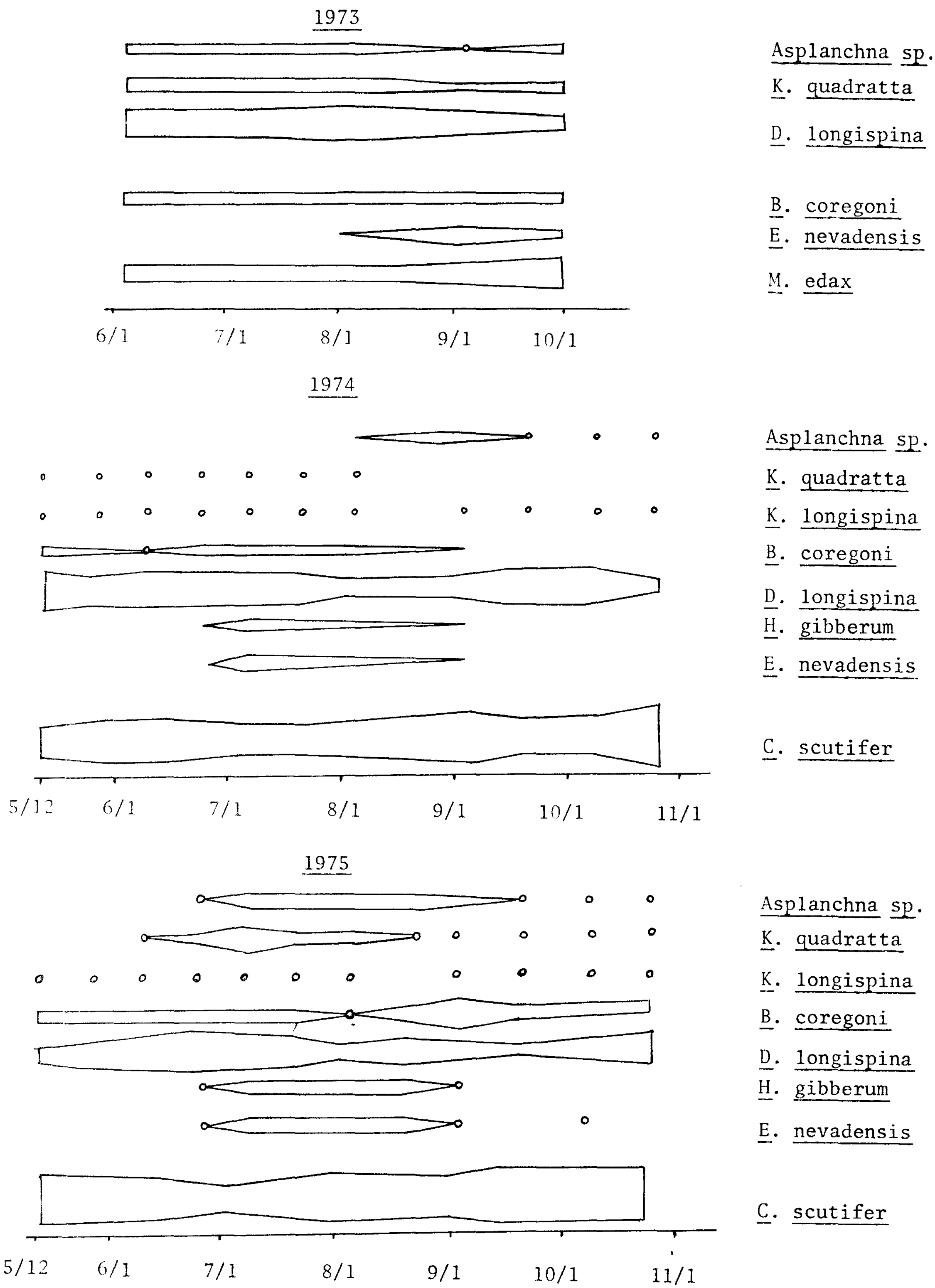

Figure 5. (Cont.) Matanuska Lake.

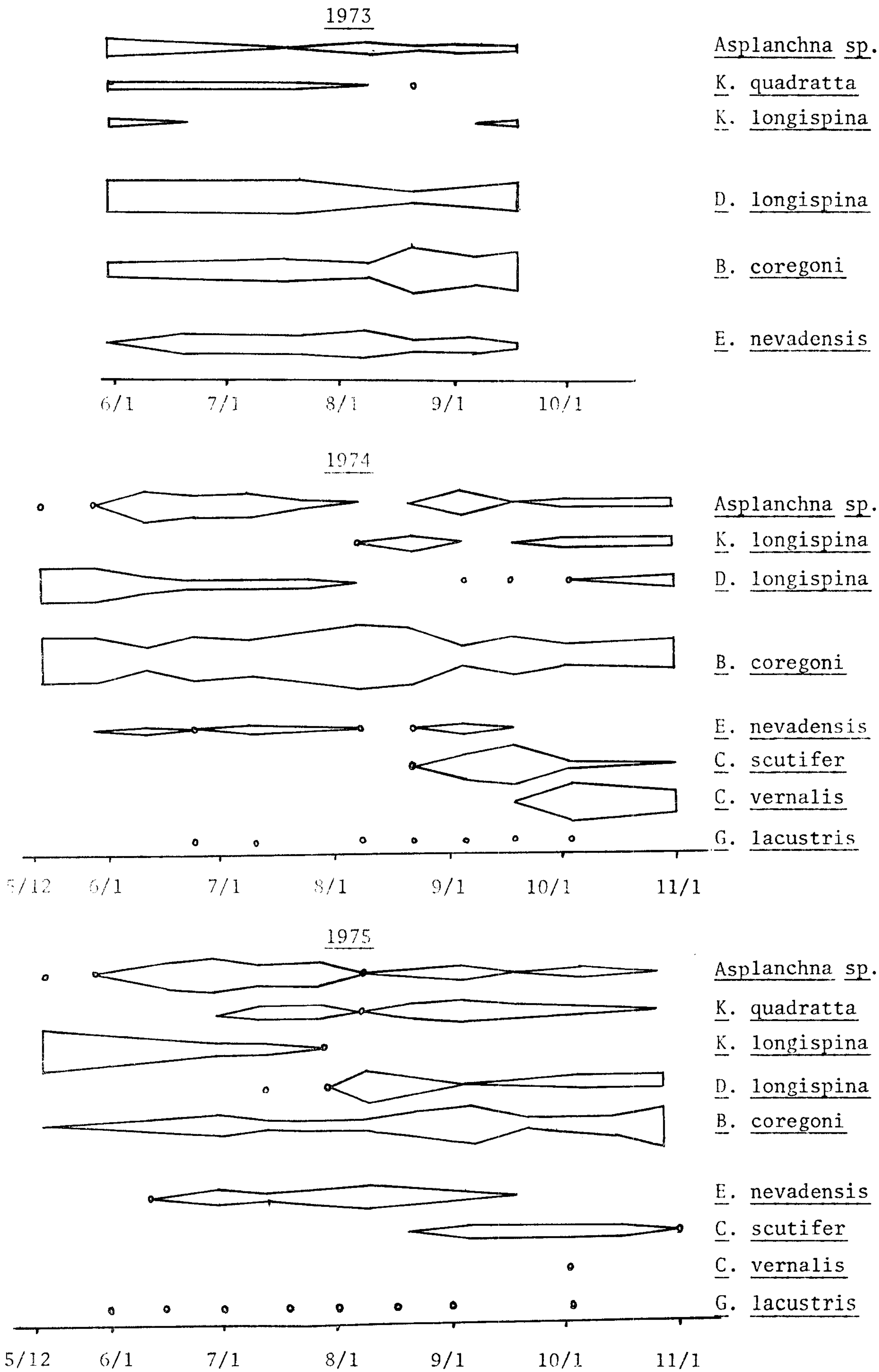

Figure 5. (Cont.) Johnson Lake.

Table 4. Organisms Occurring in Study Lakes Compiled from Plankton Samples for 1973, 1974, and 1975.

	Matanuska			Johnson			Memory		
	73	74	75	73	74	75	73	74	75
Rotifera									
Asplanchna sp.	X*	X	X	X	X	X	X	X	X
Keratella	X	0	X	X		X	X		0
Kellicottia longispina		0	0	X	X	X	X	0	
Cladocera									
Daphnia longispina	X	X	X	X	X	X	X	0	
Daphnia pulex							X		
Bosmina coregoni	X	X	X	X	X	X	X	X	X
Holopedium gibberum		X	X						
Copepoda									
Epischura nevadensis	X	X	X	X	X	X	X	X	X
Cyclops scutifer		X	X		X	X			
Cyclops capillatus							X		
Cyclops vernalis					X				
Nesocyclops edax	X				X	0			
Amphipoda									
Gammarus lacustris					X	0		0	0
Ostracoda							0		
Insecta									
Corixidae					0	0		0	0
Chironomidae					0	0		0	0

* X Denotes presence; 0 denotes occurrance less than 1%.

Memory Lake still retained slightly greater than 0.2 ppm rotenone when tested on February 26, 1974. Chinook salmon were similarly suspended in Memory Lake on April 1 at the 5 and 12-foot levels; however, 50% mortality was incurred by the third day in the bottom cages. On the fourth day 80% of the fish had died at both depths, suggesting toxic levels of rotenone were sill present (Kalb, 1975). Subsequent chemical analysis for rotenone indicated lake detoxification by the end of March.

In 1973 a variation of seasonal plankton abundance in chemically treated and untreated lakes was noted (Kalb, 1975). Kalb attributes low plankton abundance to retardation of plankton productivity by rotenone application the previous fall. Kalb also pointed out that no pre-treatment plankton samples were collected from these lakes; however, post-treatment seasonal succession of organisms suggests that early seasonal plankton production in 1973 of less complex organisms, such as rotifers and protozoans, were the initial forms to reestablish in any numbers. Species succession progressed to cladoceran or copepod dominance shortly thereafter. In 1974 cladocerans and copepods were the dominant species present in initial samples from the same lakes; and rotifers, if present at all, occurred only in small numbers (Kalb, 1975).

Kalb (1975) noted that chemical treatment appeared to retard plankton abundance in Memory Lake, as early 1974 samples were void of organisms. Plankton did not begin to reappear until the end of June beginning with Asplanchna sp., and succeeding to crustacean species. Sampling in 1975 supports Kalb's observations, as plankton appeared in late May and early June beginning with Asplanchna sp. and succeeding to crustacean species. The overall trend of plankton species dominance and catch composition by percent species abundance throughout 1975 sampling follows the same trend exhibited during 1974 sampling, which indicates return to possible previous plankton species levels.

In Johnson Lake definite changes occurred in plankton abundance and composition throughout the sampling period. Plankton abundance did not increase in early June as it had in 1974, but began to increase in August. The total plankton centrifuge volume remained below pre-treatment levels, increasing very little compared to 1974. Evidence of this is indicated in Table 3 and by comparing relative plankton species composition numbers for 1974 and 1975. In June, 1974, there were strong pulses of Daphnia longispina and Bosmina coregoni; however, in June, 1975, strengths of equivalent magnitudes did not develop for either species. Plankton volumes were increased in 1975 probably because of the noted increase in numbers of Epischura nevadensis and Cyclops scutifer. The copepod, C. vernalis, in 1974 was found to represent less than 1% of volumes in 1975. No documented data are available to indicate reasons for these effects; however, introduction of rainbow trout after lake detoxification could have altered cladoceran levels as evidenced by trout feeding behavior (Brynildson and Kempinger, 1973). The overall trend of plankton species dominance in 1975 followed that of 1974.

Throughout 1975, Matanuska Lake plankton species dominance, succession and catch composition by percent species abundance followed the same trends as 1974, indicating a stable zooplankton community (Figure 5).

After examination of plankton volumes, it appears that the spring plankton maximum occurs between mid-June and early July, followed by a decrease in July and August, and by another smaller plankton peak in September. The spring peak is probably related to available food supply which is in turn related to nutrient availability, increased daylight hours, increased light intensity, and increased water temperatures. Species composition in the spring and fall pulses were similar, both predominately composed of B. coregoni, D. longispina, and C. scutifer. July through August species composition was predominately rotifers, Asplanchna sp. and Keratella quadrata; a cladoceran, Holopedium gibberum; and a copepod, E. nevadensis.

Comparing zooplankton trends in treated lakes (Memory and Johnson) with a non-treated lake having a stable zooplankton community (Matanuska Lake), based on results of zooplankton analysis, the data indicate that treated lakes require between one to two years to reestablish a zooplankton community of previous dominance and abundance. It is apparent, however, that none of the abundant species of zooplankton were eliminated from lakes after chemical treatment. Johnson Lake results may not support this assumption, but emphasis should be placed on possible zooplankton community alteration by the subsequent introduction of trout into the system after lake detoxification. Both factors together may have had an impact on the zooplankton community.

Benthic organisms were collected and identified for each three meter depth interval from Johnson and Memory lakes (Table 5). The groups of organisms identified from Memory Lake were: amphipods, Gammarus lacustris; chironomids, Cryptochironomus and Procladius sp., caddis flies, Oecetis sp., clams, Pisidium sp.; snails, Gyrallus sp.; worms, Lumbriculus sp.; leaches, Glossophonia heteroclita; and unidentified mites. Pre- (1973) and post-(1974, 1975) treatment data indicate that none of the abundant benthic organisms were eliminated after chemical treatment. Benthic organisms found to be most abundant prior to and after chemical treatment were Pisidium sp. followed by Gammarus lacustris and Procladius sp., with only minor numbers of the other organisms present.

Benthic organisms collected at three meter intervals in Johnson Lake were of the same groups as Memory Lake. More species diversity, however, was noted with the addition of: beetles, Galerucella sp.; caddisflies, Limnephilidae; dragon flies, Somatoehlora sp.; chironomids, Einfeldia sp.; Phaenospectra sp., Polypedium sp., Tanytarsus sp., and Dierotendipes sp.; leeches, Helobdella stagnalis; worms, Ilyodrilus sp.; and unidentified mayflies, Baetidae. As in Memory Lake, pre- and post-treatment data indicate none of the abundant benthic organisms were eliminated by chemical treatment. Benthic organisms found to be most abundant prior to and after chemical treatment were chironomid species followed by Gammarus lacustris and Pisidium sp. with only minor numbers of the other organisms present. The only major change noted in three years of sampling was the increase in chironomid numbers in 1975. No explanation for this occurrence is obvious.

Table 5. Memory and Johnson Lakes Benthic Macroinvertebrates*, 1973**-1975.

Date	Identification	Group	Depth (m) 0.5	1	3	6
Memory Lake						
7/20/73	Gammarus lacustris	amphipods (a.)		0	3	0
	Procladius sp.	chironomids (c.)		0	0	
	Oecetis sp.	caddisflies (cd.)		0	0	
	Gyrallus sp.	snails (s.)		0	0	0
	Lumbriculus sp.	worms (w.)		0	0	
	Cryptochironomus sp.	chironomids (c.)		0	0	
	Dicrotendipes sp.	chironomids (c.)		0	0	
	Pisidium sp.	clams (cl.)		1	0	0
	Glossophonia heteroclita	leeches (l.)				
	Graptocorixa sp.	bugs (b.)				
	Procladius sp.	chironomids (c.)		0	0	0
8/8/73		a.			0	0
		cl.				2
		s.				0
8/23/73		a.		0	0	
		cl.		2	2	0
		s.		0		
		w.		0		
		c.			0	
9/7/73		a.		0	0	
		c.		0	0	0
		cd.		0		
		cl.		2	0	
		s.		0		
9/19/73		a.		0		0
		c.		0		1
		cl.		0		1
		s.			0	
		b.				0
6/4/74	Gammarus lacustris	amphipods (a.)	3	2	0	
	Procladius sp.	chironomids (c.)			0	
	Cryptochironomus sp.	(c.)			0	
	Dicrotendipes sp.	(c.)			0	
	Procladius sp.	(c.)			0	
	Pisidium sp.	clams (cl.)	0	1	0	
	Gyrallus sp	snails (s.)			0	
	Glossophonia heteroclita	leeches (l.)				
	Lumbriculus sp.	worms (w.)				
	Graptocorixa sp.	bugs (b.)				
6/14/74		a.	0			
		cl.	0	1	0	1
		c.	0	1		0

Table 5. (Cont.) Memory and Johnson Lakes Benthic Macroinvertebrates*, 1973**-1975.

Date	Identification	Group	Depth (m) 0.5	1	3	6
		s.	0	0		0
		w.				0
		l.		0		
6/28/74		a.	0	0	0	
		c.		0	1	
		cl.	0	2	0	0
7/12/74		a.	0		0	
		cl.	0	1	1	
		c.	0	1	1	
		s.	0	0	0	
		b.	0			
7/28/74		c.	2	1	1	1
		cl.		0	0	0
		s.	0	0	0	
8/13/74		a.	0		0	
		c.	2	1	0	0
		cl.	2	0	1	0
		s.			0	
8/27/74		a.	0	0	0	
		c.	5	3	5	
		cl.	1	1	1	0
9/16/74		a.	1	1	3	3
		c.	1		0	
		cl.	3	2	5	0
		s.	0		0	
10/2/74		a.		0	1	4
		c.			1	
		cl.		1	2	0
		b.		0		
		s.			0	
10/31/74		a.	0	1	2	3
		c.	1	0	0	0
		cl.	0		0	1
		s.			0	0
		b.		0		
		w.		0		
5/19/75	*Gammarus lacustris*	amphipods (a.)	5	4	0	
	Procladius sp	chironomids (c.)			0	
	Crytochironomus sp.	(c.)			0	
	Dicrotendipes sp.	(c.)			0	
	Procladius sp.	(c.)			0	
	Pisidium sp.	clams (cl.)	2	0	0	
	Gyrallus sp.	snails (s.)				
	Glossophonia heteroclita	leeches (l.)				

Table 5. (Cont.) Memory and Johnson Lakes Benthic Macroinvertebrates*, 1973**-1975.

Date	Identification	Group	Depth (m) 0.5	1	3	6
	Lumbriculus sp.	worms (w.)		0		
	Graptocorixa sp.	bugs (b.)				
6/5/75		a.				0
		c.		1		0
		cl.	0	1	0	0
		s.		0		0
		l.	0	0		
6/30/75		a.	0		0	
		c.		0	0	
		cl.	0	2	0	0
7/15/75		a.	0		0	
		c.		0	1	
		cl.	0	1	1	
		s.	0	0	0	
		b.	0			
7/28/75		c.	3	1	1	0
		cl.	0	0	0	0
		s.		0	0	
8/12/75		a.	0		0	
		c.	2	1	0	0
		cl.	2	0	1	0
		s.			0	
8/28/75		a.	0	0	0	
		c.	5	3	5	0
		cl.	1	1	0	
9/12/75		a.			0	
		c.	5	5	5	0
		cl.	1		0	0
		l.		0		
9/22/75		a.				0
		c.	0	3	3	0
		cl.	0	0	0	0

Date	Identification	Group	Depth (m) 0.5	1	3	6	9	12
Johnson Lake								
7/20/73	Gammarus lacustris	a.	0					
	Galerucella sp. (bettles-bt.)	bt.	0					
	Limnephilidae	cd.	0	0				
	Chironomus sp.	c.	0			0	3	
	Procladius sp.	c.	0			0	0	
	Einfeldia sp.	c.			0			

Table 5. (Cont.) Memory and Johnson Lakes Benthic Macroinvertebrates*, 1973**-1975.

			Depth (m)					
Date	Identification	Group	0.5	1	3	6	9	12
	Gyrallus sp.	s.	0			0		
	Glossophonia sp.	l.		0				
	Helobdella sp.	l						
	Peloscolex sp.	w.						
	Ilyodrilus sp.	w.						
6/6/75		a.	0	1	0	0		
		c.		0	0	0		
		cl.	3	2	2	1		
		l.				0		
		cd..		0				
		s.		0	0	0	0	
6/18/75		a.	1		0	1		
		c.	0	0		0		
		cl.	2	1	0	0	0	
		s.	0			0	0	
7/1/75		a.	1		0	1		
		c.	0	0		0		
		cl.	2	1	0	0	0	
		s.	0			0	0	
7/15/75		a.	1	3	3	0	0	0
		c.	0		3	0	0	
		cl.	5	0	1	0	0	
		s.		0				
		l.		0				
7/28/75		a.	2	1	2	1		
		c.	3	0	5	1		
		cl.	3			0		
		s.						
		l.				0		
8/12/75		a.	3	4	1	1	0	0
		c.	1	5	5	0		
		cl.	2	1	3	1	0	
		s.		0				
8/28/75		a.	2	5	1	1		
		c.	5	5	5	0	0	
		cl.	0	1	1	0		
		s.					0	
9/10/75		a.	2	2	2	1		0
		c.	5	5	5	4		
		cl.	0	1		0	0	
9/22/75		a.	0	0	2	0	0	0
		c.	3	5	5	4		
		cl.	0					
		s.				0		
		l.		0				

Table 5. (Cont.) Memory and Johnson Lakes Benthic Macroinvertebtates*, 1973**-1975.

Date	Identification	Group	Depth (m) 0.5	1	3	6	9	12
	Polypedium sp	c.			0			
	Tanytarsus sp.	c.			1		0	
	Pisidium sp.	cl.	2	2				
	Gyrallus sp.	s.		0				
	Somatochlora sp. (dragonflies-d.)	d.		0				
	Glossophonia sp.	l.		0	0			
	Helobdella sp.	1						
	Peloscolex sp.	2.				0	0	
	Ilyodrilus sp.	w.						
8/8/73		a.	0	2	0			
		cl.	3	2	1	20		0
		s.	0	1	0			0
		c.		0	1	0	2	
		cd.		0				
		w.		0	0			
8/20/73		a.	0	1	1			
		cl.	2	1	2			
		d.	0	0				
		s.						
		c.		1	0	0	2	
		d.						
		l.		0	0			
		s.	1	0	0			
9/7/73		a.	1	0	1			
		cl.	1	2	2			
		s.	0		0	0		
		w.	0	0			1	
		c.		0		1	0	
		cd.			0			
9/17/73		a.	0	0	0			
		cl.	1	0	0			
		s.	0	0	0			
		c.	0			0	0	
		w.					0	
5/20/75	*Gammarus lacustris*	a.	0	0	0	0		
	Galerucella sp.	bt.						
	Limnephilidae	cd.	0					
	Chironomus sp.	c.					0	
	Procladius sp.	c.			0			
	Einfeldia sp.	c.						
	Polypedium sp.	c.						
	Tanytarsus sp.	c.						
	Pisidium sp.	cl.	1	0	0	0	0	

Table 5. (Cont.) Memory and Johnson Lakes Benthic Macroinvertebrates*, 1973**-1975.

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* Number of organisms is denoted as: 0-10 = 0, 10-20 = 1, 20-30 = 2, 30-40 = 3, 40-50 = 4, 50 = 5.

** La Perricre identified all benthic organisms in 1973.

*** Benthic macroinvertebrates from Johnson Lake in 1974 were unavailable for indentification.

Periphyton:

Epilithic periphyton comprises all organisms (except macrophytes), including sponges and Bryozoa, which are attached on inorganic substrates.

Inorganic matter in biomass samples from Matanuska, Johnson, and Memory lakes may have caused excessive dry and ash weight; the degree of this could not be determined. This anomaly caused problems in interpreting the data initially; however, it was assumed that the periphyton biomass accumulated at identical rates in the same substrate location of each lake. Recommended substrate exposure is 14 days, but to insure sufficient periphyton colonization samples were periodically checked and removed after 30 days. Biomass data could not be determined for the first sampling period because of vandalism to glass substrates. Subsequent sites were located and substrate markers placed below the waters surface.

Regression analysis of periphyton biomass (g/m^2) determined for Memory, Johnson, and Matanuska lakes on a monthly sampling basis yielded a high correlation of data, $r=0.97$, to the morphoedaphic index, Figure 6, indicating possible agreement of the two systems.

Growth and Survival of Stocked Rainbow Trout:

Game fish stocking substantially contributes to the recreational fisheries though it does not always produce desired results in the varied and often harsh environments of Alaska. It is necessary that the effects of these conditions be minimized by use of game fish strains that are well suited to recipient waters.

Prior to 1975 rainbow trout, S. gairdneri, eggs from Ennis, Montana and Winthrop, Washington supported the state's trout cultural program. Both strains have extensive domestic histories, a feature that may cause them to be vulnerable to Alaska's environmental conditions. Because of this and because of the risk of possible importation of disease organisms, Alaskan brood stocks are being developed and evaluated.

Initial egg sources for this stock are from Swanson River on the Kenai Peninsula and the Naknek River and Talarik Creek in Bristol Bay. Bristol Bay trout were chosen primarily for their large size, whereas the Kenai fish were selected because of a lake rearing background and a possible greater tolerance to threespine stickleback competition.

Canoe and Reed lakes, located in the Matanuska Valley, were stocked in October, 1974 with fin clipped Swanson River and Talarik Creek origin trout. Both lakes have extensive domestic trout stocking histories and both have been previously rehabilitated; however, Canoe Lake is considered very productive while Reed Lake is much less fertile. Tigger Lake, near Talkeetna, was planted with Naknek River fish to assess the strain's ability to cope with threespine stickleback.

The program using imported brood stock is designed to compliment the Alaska brood stock program. Ennis rainbow trout were chosen for evaluation because: (1) the strain features December spawning which permits early summer fingerling stocking, (2) early liberation of Ennis trout also

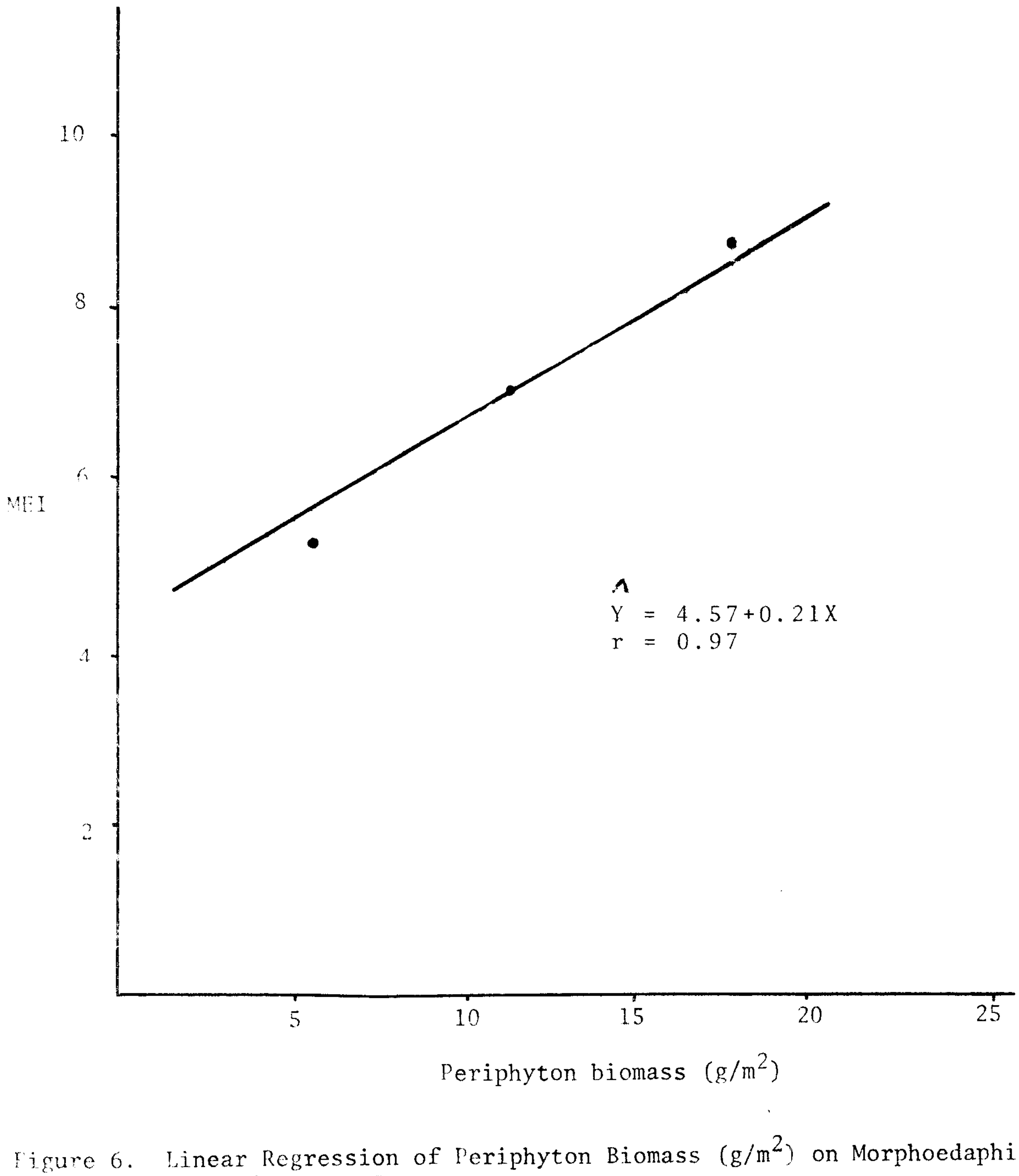

Figure 6. Linear Regression of Periphyton Biomass (g/m^2) on Morphoedaphic Index (MEI), 1975.

vacates hatchery space required for rearing Alaska fry produced from spring spawning stocks, and (3) Ennis strain's extensive cultural background will accommodate comparative studies between Alaska and domestic brood programs.

The British Columbia stocking curve (Smith et al, 1969) was developed to equate number of fry to fingerlings so numbers of fry planted produced trout equal in number to trout produced by a fingerling plant of stated size. This method, described by Kalb (1974), is currently being utilized and evaluated in lake management programs of the Matanuska-Susitna Valleys. Morphometric data for the study lakes in the Matanuska-Susitna Valleys are presented by Kalb (1975).

Previous plants of Ennis and Winthrop strains of rainbow trout stocked in Long Lake (1974) should have been present in equal numbers at age 1+. Gill net catches of May 9 and September 17, 1974 indicate Winthrop strain present in slightly greater numbers than the Ennis strain (Kalb, 1974). This suggests that the conversion schedule may overestimate numbers of fry needed to equal numbers of the fingerling plant (Kalb, 1974).

In addition to Long Lake, one year later both Marion and Christiansen lakes were stocked with Winthrop fry and Ennis fingerling as determined from the British Columbia stocking schedule. The variables, i.e., fish strain, fish size, time of stocking as well as unmeasured ecological lake factors (Kalb, 1975), are assumed equivalent and the analysis of growth and numbers is to be considered for each strain.

Winthrop and Ennis strain rainbow trout were collected by gill net from Marion and Christiansen lakes on May 27 and May 29, 1975, respectively. Length-frequency for the captured fish from Marion Lake indicated a composition of 55 Winthrop strain greater than Ennis (Figure 7A). This indicates an overestimate of the conversion schedule of Winthrop fry needed to equal numbers of Ennis fingerling in Marion Lake. Further analysis of the British Columbia stocking schedule was not accomplished in Marion Lake because it was impossible to differentiate the two strains on the basis of length frequency (Figure 7B).

Mean length and weight for Winthrop fish in Marion Lake sampled on May 27 was 167 mm and 55 g, respectively, and 219 mm and 122 g for Ennis fish. Student's t-test indicates a 95% probability that the difference between mean length and weight of Winthrop and Ennis fish is significant.

Additional growth information is obtained by regressing weight on fork length for the May 27 Marion Lake sample. Regression equations for Winthrop and Ennis fish are $Y=97.6+0.91X$ and $Y=257.7+1.73X$, respectively. Analysis of regressions indicate that the Ennis stock gained weight and increased in length at a greater rate than did Winthrop stock, and analysis of covariance at the 99% confidence level indicated that the regression lines were significantly different.

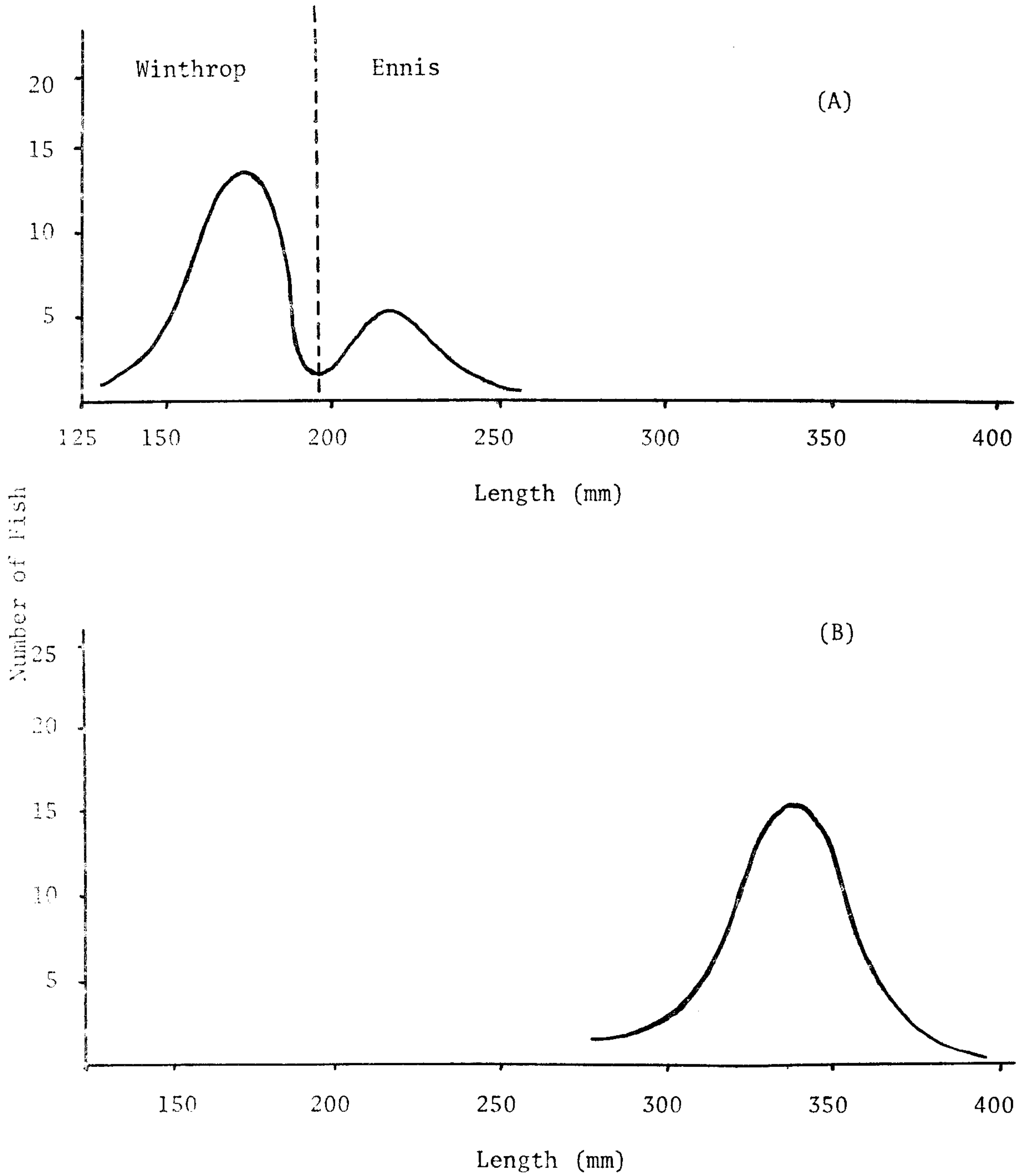

Figure 7 . (A) Separation of Winthrop fry plant from Ennis fingerling plant by differentiation in length-frequency of rainbow trout collected by gillnet, May 27 - May 29, from Marion Lake, 1975.

(B) Lack of differentiation in length-frequency of Winthrop-Ennis strains collected by gillnet, September 9 - September 12, from Marion Lake, 1975.

Length-frequencies for Winthrop and Ennis strains in Christiansen Lake, (Figure 8A) indicate a smaller number of Winthrop fish than Ennis fish. Further analysis of the stocking schedule could not be done due to lack of stock differentiation (Figure 8B).

Mean length and weight for Winthrop fish in Christiansen Lake sampled on May 29 was 1976 mm and 66 g, respectively, and 221 mm and 133 g for Ennis fish. Student's t-test indicates a 95% probability that the difference is significant between means of Winthrop and Ennis fish.

Regression equations of $\hat{Y}=68.67+0.76X$ for Winthrop fish and $\hat{Y}=216.35+1.55X$ Ennis fish sampled from Christiansen Lake on May 29 indicate the Ennis stock gained weight, and increased in length at a greater rate than Winthrop stock. Analysis of covariance indicated that the regression lines were significantly different at the 99% confidence level.

A comparison of condition factors for May 27 and May 29 samples of Ennis and Winthrop strains in Marion and Christiansen lakes yielded no significant difference within each lake. Condition factors of Winthrop-Ennis strains between the lakes, however, were only slightly different with Christiansen Lake fish more robust. Condition factors determined from fish sampled from both lakes in August indicated no significant difference. Due to lack of stock differentiation, August condition factors could not be determined for the individual strains within each lake (Figure 8B). Despite no significant difference in earlier condition factors between strains in both lakes, linear regressions indicate the major growth in length to weight for Marion Lake fish occurred between May 27 and August 11. High slope values (Table 6) of 3.63 for Marion fish and 3.54 for Christiansen fish sampled on August 18 and September 12, respectively, exceed the ideal isometric cube value due to active feeding and increase in weight throughout the summer growth period.

Rainbow population estimates for Marion and Christiansen lakes were determined after a matching plant of hand selected rainbows from Fort Richardson cooling ponds, equal in size to May 27 and May 29 gill net caught rainbow from both lakes, were marked and stocked. On June 4 Christiansen Lake received 600 fish and Marion Lake 300 fish to constitute the marked matching plants. Mark and recapture data are summarized in Table 7.

Estimation of trout population size in Marion Lake during the month of May, as determined from August-September sampling by using Chapman's modification of the Petersen estimator, (Richer, 1958) was 1,158 Winthrop strain with a 95% confidence range of $835<N<2,161$. This represents a survival of 7% with an interval of 5-13%. The population estimate for Ennis fish was 491 with a 95% confidence range of $278<N<720$. This relates to a survival of 11% for Ennis fish with an interval of 6-16%.

Population size of Winthrop strain in Christiansen Lake using Chapman's modification was determined to be 806 fish with a 95% confidence range of $592<N<1,184$. This represents a 1% survival with an interval of 0.1-6.0%. The population estimate for Ennis fish was 972 with a 95% confidence range of $711<N<1,421$ and a survival of 7% at an interval of 2.8-14%.

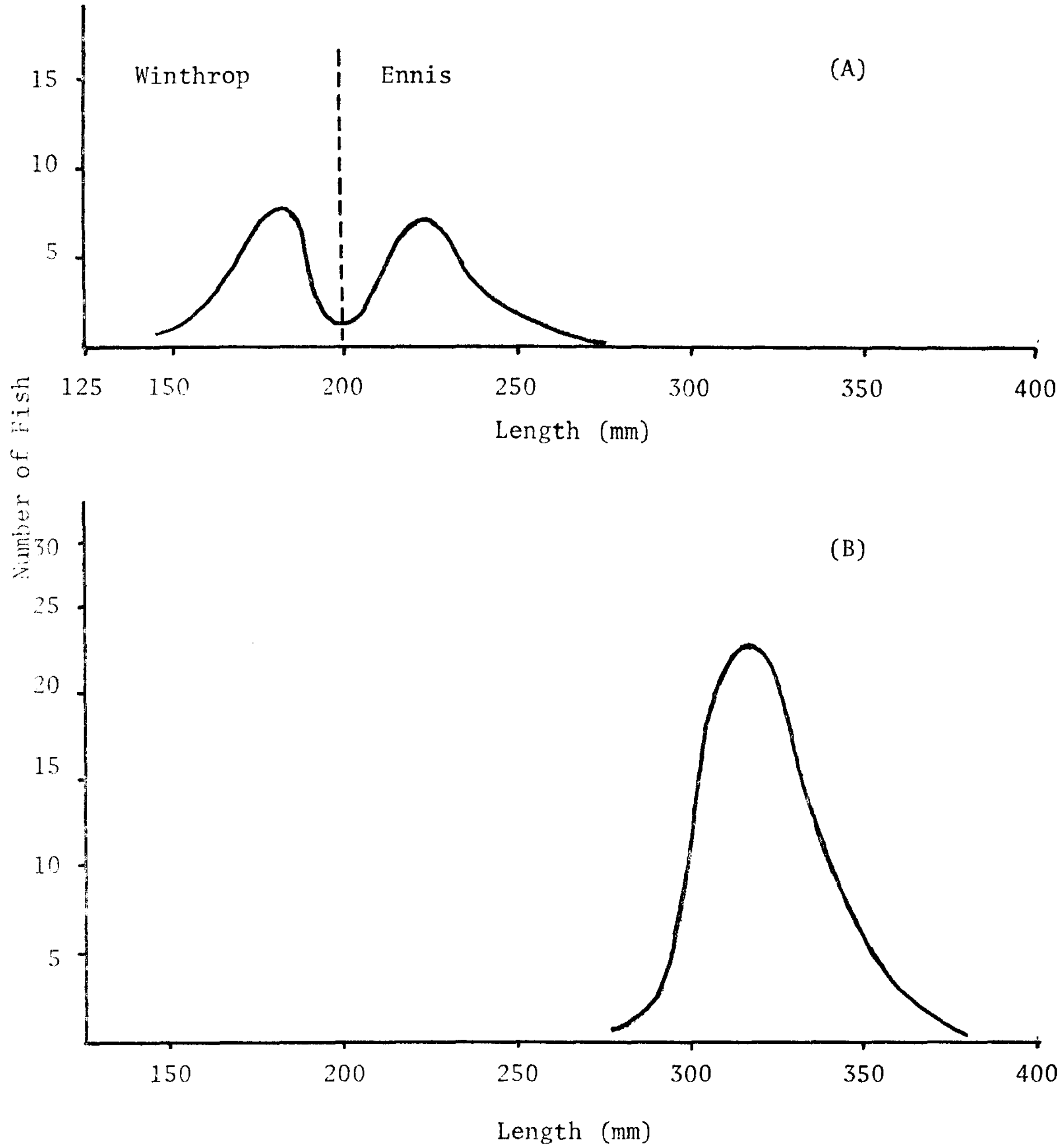

Figure 8 . (A) Separation of Winthrop fry plant from Ennis fingerling plant by differentiation in length-frequency of rainbow trout collected by gillnet, May 29 - May 30, from Christiansen Lake, 1975.

(B) Lack of differentiation in length-frequency of Winthrop Ennis strains collected by gillnet, August 18 - August 22, from Christiansen Lake, 1975.

Table 6. Summary of Length-Weight Regression Data for Stocked Game Fish, 1975.

RAINBOW TROUT

Lake	Date	Strain*	Sample Size	Regression Equation (Y=a+bX)	Correlation Coefficient (r)
Christiansen	5/29/75	W,E	76	Y=-150.4 + 1.25X	0.90
	8/18/75	W,E	149	Y=-687.3 + 3.63X	0.89
Marion	5/27/75	W,E	109	Y=-150.3 + 1.23X	0.95
	8/11/75	W,E	121	Y=-421.2 + 2.68X	0.91
	9/12/75	W,E	135	Y=-667.6 + 3.54X	0.85
Reed**	10/ 2/75	S (RV)	123	Y=-149.7 + 1.16X	0.96
	10/ 2/75	T (LV)	148	Y=-141.4 + 1.12X	0.95
	10/ 2/75	T (NM)	253	Y=- 91.1 + 0.85X	0.86
Tigger	10/14/75	N	31	Y=-227.9 + 1.71X	0.97
Long	10/ 9/75	S	83	Y=-365.1 + 2.21X	0.95
	10/ 9/75	T	46	Y=-287.2 + 1.84X	0.93

* W = Winthrop, Wash.; E = Ennis, Montana; N = Naknek, Alaska; S = Swanson River, Alaska; T = Talarik Creek, Alaska.

** RV = right ventral clip, LV = left ventral clip, NM = no mark.

Table 7. Summary of Mark and Recapture Data, 1975.

Lake	Date	Method of Capture	Strain	Marked Fish at Large M	Number Caught C	CM	Σ CM	Recaptures R
Marion	8/12/75	Gillnet	W,E*	300	46	13,800	13,800	12
	8/13/75	Gillnet	W,E	288	28	8,064	21,864	2
	8/14/75	Gillnet	W,E	286	45	12,870	34,740	11
Marion	9/ 9/75	Gillnet	W,E	275	54	14,850	49,590	5
	9/10/75	Gillnet	W,E	270	31	8,370	57,960	3
	9/11/75	Gillnet	W,E	267	29	7,743	65,703	10
	9/12/75	Gillnet	W,E	257	14	3,598	69,301	1
Christianson	8/19/75	Gillnet	W,E	600	69	41,400	41,400	23
	8/20/75	Gillnet	W,E	577	29	16,733	58,133	10
	8/21/75	Gillnet	W,E	567	36	20,412	78,545	9
	8/22/75	Gillnet	W,E	558	15	8,370	86,915	8

* W-Winthrop, Wash., E-Ennis, Mont.

Age 1+ Ennis and Winthrop rainbow in Marion Lake should have been present in approximately equal numbers as determined by the British Columbia stocking schedule. Winthrop fry numbers, as determined from population estimates, however, were greater than Ennis fingerling by 42%. The conversion schedule overestimated numbers of fry needed to equal numbers of the fingerling plant. In Christiansen Lake, Winthrop strain composition was less than Ennis strain composition by a ratio of 83/100 underestimating the numbers of fry needed to equal survival of the fingerling plant.

Evaluation of Winthrop fry strain in Memory Lake and Swanson River and Talarik Creek strains in Canoe Lake could not be analyzed due to winter-kill in 1975.

Irene Lake was stocked in 1975 with Winthrop fry and Ennis fingerling as determined by the British Columbia stocking schedule. Evaluation of the stocking schedule will follow in 1976.

Ennis fingerlings stocked in Johnson Lake, 1975, will be analyzed after spring sampling in 1976.

Short Pine lake on the Kenai Penisula was stocked with Winthrop and Ennis strains in 1973. Preliminary sampling in 1974 indicated a slightly superior growth by Ennis stock. A final fall sample on October 4, 1974, indicated no significant difference between the two strains (Kalb, 1975). In 72 hours of 1975 fall gill net sampling only 36 fish, 25 Ennis and 11 Winthrop, were caught. Regression equations for Ennis and Winthrop strains were respecitively calculated as $Y=212.68+1.07X$, $r=0.15$, and $Y=769.35+4.42X$, $r=0.91$. Ennis strain fish had a respective mean length and weight of 435 mm and 1,186 g, with respective standard deviations of 30 mm and 435 g. Winthrop strain fish had respective mean length and weight of 447 mm and 1,211 g, with respective standard deviations of 45 mm and 217 g.

Subsequent sampling to increase sample size and to make mark-recapture population estimates of Winthrop-Ennis strains was curtailed to avoid unnecessary mortality on the current plant of fish.

To date only Tigger Lake, with stickleback populations, in the upper Cook Inlet drainage has been stocked with Naknek rainbow trout strain. Only 31 fish, 0.6% of the original plant of 4,600, were captured in three days of gill-netting. A condition factor of 1.44 and regression equation of $Y=-227.1+1.71X$ were determined from data collected on October 14. It is not know whether low dissolved oxygen levels, low productivity, or the presence of stickleback influenced low gill net catches of the original plant.

Reed Lake has a surface area of 19.5 acres, 20 foot maximum depth, 10.4 foot mean depth, and the littoral area comprises 70% of the lake. Its low MEI value, 4.9 in comparison to other Valley lakes (Watsjold, 1976, in press) indicates low productivity. Also, in comparison to other managed Valley lakes the stocking history is minimal. There were only four previous plants of rainbow trout beginning in 1965 with additional plants in 1970, 1971, and 1972. Coho salmon, Oncorhynchus kisutch, (Walbaum) and Arctic grayling, Thymallus arcticus (Pallas), were stocked in 1967 and 1969. Fall gill-netting of stocked rainbow trout in 1970, 1971, and 1972 indicated low survivals of initial plants as catches yielded less than 0.5% of the initial plant at 0.13 fish per gill net hour.

On October 10, 1974, Reed Lake was stocked with 1,500 right ventral fin clipped Swanson River rainbows, 2,578 left ventral fin clipped Talarik Creek rainbows, and 3,000 unmarked Talarik Creek rainbows. Talarik Creek fish were stocked at 98 fish/lb. and Swanson River fish at 132 fish/lb., Table 8.

Reed Lake is probably the most unique study lake involved in evaluation of survival and effect of fin removal on Talarik and Swanson rainbow trout strains. Talarik fish were chosen primarily for their large size, whereas the Swanson River fish were selected because of a lake rearing background and a possible tolerance to stickleback competition.

A Chi-square analysis, Table 9, indicated a significant difference (p 0.01, df=2) in gill net catches of marked Swanson-Talarik rainbows and unmarked Talarik rainbows. Both Swanson and unmarked Talarik rainbows exceeded the expected capture value. A higher catch of unmarked Talarik rainbow was expected due to regeneration of pelvic fins of the marked Tarlarik fish, which corresponds with a lower catch of marked Talarik fish. Chi-square analysis of current data indicate: (1) significant difference (p 0.01) in catches between marked fish and unmarked fish, (2) significant difference (p 0.01) in catch of marked fish, (3) significant difference (p 0.01) in catch of marked Talarik fish to unmarked Talarik fish, and (4) significant difference (p 0.01) in catch of marked Swanson fish to unmarked Talarik fish. To test the possible effect on data caused by fin regeneration, the catch in excess of the expected value for unmarked Talarik fish was divided and distributed in appropriate proportion to categories of marked fish. Chi-square analysis showed (1) no significant difference (p 0.01) in catches between marked and unmarked fish, (2) significant difference (p 0.01) in catches of marked fish, and (3) significant difference (p 0.01) in individual catches of both marked Swanson-Talarik fish and unmarked Talarik fish.

In both Chi-square analyses the results were skewed by the higher than expected catches of marked Swanson fish. Number and size differentiation of rainbows stocked does not seem significant as Swanson fish were stocked at a smaller size and in fewer numbers (Table 10); however, greater than expected catches could be explained by better survival.

Population estimates were not made in Reed Lake due to lack of an available marked Talarik-Swanson strain matching plant; but an indication of representative survival may be gained from gill net catches. Gill-

Table 8. Lake Stocking Schedule, 1974-1975.

Lake	Date Stocked	Strain*	Size (Fish/lb.)	Stocking Density (Fish/acre)	Number of Fish
Canoe	10/ 1/75	T	226	125	2,625
		S	292	125	2,625
Big No-Luck	10/ 1/75	T	225	34	2,300
		S	296	66	4,500
Little No-Luck	8/13/75	E	126	100	3,400
Johnson	7/ 6/75	E	207	300	12,000
Marion	6/ 4/75	W	4	3	300
Christiansen	6/ 4/75	W	4	3	600
Long	6/20/75	T	11	41	3,056
		S	11	14	1,000
Reed	10/10/74	T	98	279	5,578
		S	132	75	1,500
Tigger	9/26/74	N	155	200	4,600

* T - Talarik Creek, Alaska
S - Swanson River, Alaska
W - Winthrop, Washington
E - Ennis, Montana
N - Naknek, Alaska

Table 9. Catch by Gillnet of Respective Strains of Marked and Unmarked Rainbow Trout in Reed Lake, 1975.

Strain	Identifying Characteristic*	Number Stocked	Number Caught
Swanson River	RV	1,500	123
Talarik Creek	LV	2,578	148
Talarik Creek	NM	3,000	253
Total		7,078	524

Categories		Strain and Identification Swanson (RV)	Talarik (LV)	Talarik (NM)
Gillnetted	Observed	123	148	253
	Expected**	111	191	222
Estimated Non-Gillnetted	Observed	1,377	2,430	2,747
	Expected	1,266	2,239	2,525

* LV, left ventral; RV, right ventral; NM, no mark.
** Expected frequency equals the proportion at time of planting times total gillnetted rainbow.

Table 10. Summary of Length-Weight Data of Stocked Game Fish, 1975.

Lake	Date	Method of Capture	Fish* Strain	No. Captured	(Length (mm) Range	Mean	S.D.	(Weight (g) Range	Mean	S.D.	Condition** Factor
Christiansen	5/29	Gill Net	W, E	76	103-256	202	30	45-190	103	42	1.24
	8/18	Gill Net	W, E	149	389-375	326	16	327-871	498	77	1.43
Marion	5/27	Gill Net	W, E	109	132-254	179	26	36-218	72	34	1.25
	8/11	Gill Net	W, E	121	150-375	299	36	68-753	381	109	1.42
	9/12	Gill Net	W, E	135	273-378	335	22	294-743	494	94	1.31
Reed***	10/ 2	Gill Net	S(RV)	123	150-236	180	16	41-141	61	19	1.02
	10/ 2	Gill Net	T(LV)	148	158-241	183	16	41-150	65	19	1.07
	10/ 2	Gill Net	T(NM)	253	158-238	182	20	45-136	65	20	1.08
Tigger	10/14	Gill Net	N	31	150-273	209	41	41-264	131	71	1.44
Long	10/ 9	Gill Net	S	83	177-325	247	32	54-400	180	75	1.19
	10/ 9	Gill Net	T	46	181-300	245	27	68-286	166	54	1.12

* W = Winthrop, Wash., E = Ennis, Montana, N = Naknek, Alaska, S = Swanson River, Alaska, T = Talarik Creek, Alaska.

** $C = \frac{100,000}{L^3} W$

*** RV = right ventral clip, LV = left ventral clip, NM = no mark.

netting one year after stocking yielded a total catch of 524 fish, or 5.24 fish per gill net hour, which represents 7% of the original stocking, or 8% marked Swanson, 5% marked Talarik, and 8% unmarked Talarik fish. Population composition by percent for each strain at time of stocking was 21% marked Swanson, 42% marked Talarik, and 36% unmarked Talarik. Percent composition by strain after gill-netting was 23% marked Swanson, 28% marked Talarik, and 48% unmarked Talarik.

Further analysis of stock by origin was conducted after results from hook and line fishing through ice were compiled. Over a ten-man-hour total fishing period, 120 fish were caught. This represented a catch of 12 fish per hour resulting in captures of 25 marked Swanson, 42 marked Talarik, and 53 unmarked Talarik, or by respective percent composition, 21, 35, and 44. Comparing the respective capture percentages of fish strain resulting from hook and line effort and strain percentages from gill net catches, there seems to be no indication of outstanding differences between the two capture methods.

Discussion of growth for marked Swanson, marked Talarik, and unmarked Talarik rainbows is analyzed from accumulated data which are summarized in Tables 9 and 10. Mean lengths and weights for marked Swanson, marked Talarik, and unmarked Talarik fish were 180, 183, and 182 mm and 61, 65 and 65 g, respectively. Respective condition factors were 1.02, 1.07, and 1.08. Student's t-test analysis of the data indicate: (1) no significant difference ($p<0.05$) in mean fork length of marked Swanson and marked Talarik fish, (2) no significant difference ($p<0.05$) in mean fork length of marked Swanson and unmarked Talarik fish, (3) significant difference ($p<0.05$) in mean weight of marked Swanson fish compared to marked Talarik and unmarked Talarik fish, and (4) significant difference ($p<0.05$) in mean fork length, mean weight, and condition factor of marked Talarik and unmarked Talarik fish. Snedecor (1956) indicates that one should be cautious in making conclusions when t-value is close to one in the t-distribution table. This is important in consideration of t-value 2.01 for comparison of mean weight of marked Swanson fish to either marked or unmarked Talarik fish when t-table value ($p<0.05$) is -1.96 to 1.96.

Long Lake was stocked in the spring of 1975, with 1,000 adipose clipped Swanson River rainbow at a mean length and weight of 159 mm and 43 g, respectively, and 3,056 unmarked Talarik rainbow at a mean length and weight of 160 mm and 41 g, respectively. Subsequent gill-netting yielded catches of 81 Swanson fish and 46 Talarik fish. Chi-square analysis (p 0.01, d.f.=1) of data.(Table 11), indicate significant difference in catches between marked Swanson and unmarked Talarik fish. More marked Swanson fish than expected were captured as opposed to the fewer unmarked Talarik fish caught.

Table 11. Catch by Gill Net of Marked Swanson River and Unmarked Talarik Creek Rainbow Trout Strains in Long Lake, 1975.

Categories		Groups Swanson Marked*	 Talarik Unmarked
Gill Netted	Observed	81	46
	Expected**	26	101
Estimated Non-Gill Netted	Observed	929	3,910
	Expected	903	3,809

* Swanson were marked by removal of the adipose fin.
** Expected frequency equals the proportion at time of planting, times total gill netted rainbow.

Student's t-test analysis of Long Lake data indicates: (1) no significant difference ($p<0.05$) in mean fork length of marked Swanson and unmarked Talarik fish and (2) significant difference ($p<0.05$) in mean weight of marked Swanson and unmarked Talarik fish. Marked Swanson fish are significantly heavier than unmarked Talarik fish.

Population estimates were not made in Long Lake due to lack of an available marked matching plant; however, an indication of representative strain survival may be made from the fall gill net catch. Composition by percent for each strain at time of stocking was 20% marked Swanson and 80% unmarked Talarik. Gill-netting percent composition by strain was 63% marked Swanson and 37% unmarked Talarik.

Growth of Hatchery Fish:

Talarik and Swanson rainbow trout strains were randomly sampled from Elmendorf cooling ponds on June 19 and September 29, 1975. On June 19 a 50 fish Swanson strain sample had respective average length and weight of 159 mm and 43 g and the respective length and weight of 100 Talarik strain fish was 160 mm and 42 g. Student's t-test indicates a 95% probability that the difference in means of length and weight of the two strains on June 19, 1975, was not significant. Student's t-tests of the same strains on September 29 indicates a 95% probability of no significant difference in mean lengths; however, mean weights were significantly different. Mean length and weight of Swanson strain was 209 mm and 112 g and mean length and weight of Talarik strain was 205 mm and 89 g.

DISCUSSION

Assessment of estimators of biological productivity in Matanuska-Susitna Valley lakes includes data analysis of plankton, periphyton, chlorophyll a, phaeopigments and fish yield. Another estimator of biological productivity is derived from a measure of nutrient concentration and morphomoemetry of a lake (Ryder et al., 1974); its use as an applicable index is described in detail by Watsjold (1976, in press).

Based on the plankton index (PI), study lakes were arranged by numerical value and accordingly ranked as to their relative productivity. Comparing plankton values determined in 1975 with those of 1973 and 1974, study lakes were found to rank at the same previous relative productivity. Regression analysis of the PI on morphoedaphic index (MEI), despite differing PI for each lake from 1973, 1974, and 1975 indicated a significant correlation in the two indices. This analysis also takes into account that chemical treatment of Matanuska, Memory, and Johnson lakes had no effect on relative ranking of lakes when using plankton index as an indicator of biological productivity.

Another potential indicator of biological productivity is the accumulation of epilithic periphyton on introduced substrates. A regression analysis of periphyton biomass, determined for Memory, Johnson, and Matanuska lakes, yielded a high correlation to MEI ($r=0.97$), indicating agreement of the two indices.

Alteration of the zooplankton community in study lakes did not occur after chemical treatment. A comparison of zooplankton trends and plankton volumes of treated lakes (Memory and Johnson) with a lake exhibiting a stable zooplankton community (Matanuska Lake) demonstrated that treated lakes require between one to two years to reestablish a zooplankton community of previous dominance and abundance. An analysis of PI, MEI and periphyton values of an unproductive lake, such as Memory, indicate that low nutrient value of lake waters may slow the reestablishment of zooplankton. Sampling of benthic organisms indicates none of the benthos were eliminated or abundance altered after recovery from chemical treatment.

Trout stocking in chemically treated lakes of low nutrient value should be delayed to allow maximum zooplankton recovery. In more productive lakes stocking should be shortly after breakup so the fish can take advantage of the increased food available at that time, thus increasing their chance for survival.

Fish survival is influenced by the biological productivity of a lake's waters. Watsjold (1976, in press) evaluates and categorizes lakes on the basis of their morphoedaphic index; but, emphasis should also be placed on the highly significant correlations of plankton index and periphyton biomass to the MEI.

Population estimates of trout in Marion and Christiansen lakes, both of which have a low MEI, indicate respective survivals of 9% and 3% of the original trout stocking; however, the percent survival of fish in both lakes is not indicative of fish growth. Slope values determined from length-weight regressions for Marion and Christiansen Lake fish greatly exceed the ideal isometric cube value due to active feeding and increase in weight throughout the summer. In contrast, slope values determined for fall gill-netted fish from lakes of high MEI are noticeably smaller. This indicates a high mortality of stocked fish in low productive waters.

Population sizes of Winthrop and Ennis strains in Marion and Christiansen lakes should have been present in approximately equal numbers as determined by the British Columbia stocking schedule. In Marion Lake, Winthrop fry composition was greater than Ennis fingerling composition, thus the conversion schedule overestimated fry needed to equal survival of the fingerling plant. In Long Lake, with the same two strains, Kalb (1975) also found the same overestimation of fry to fingerling. In Christiansen Lake (1975), Winthrop fry composition was slightly less than Ennis fingerling composition, due to underestimation of the numbers of fry needed to equal survival of the fingerling plant. The difference is so slight, however, that the stocking schedule may be applicable to Christiansen Lake. Future evaluation of the schedule using Winthrop-Ennis strains will be determined after sampling of Irene Lake in spring, 1976.

Evaluation of the Winthrop-Ennis strains in Marion and Christiansen lakes yielded no significant difference in condition factors within each lake; however, condition factors of Winthrop-Ennis strains between both lakes indicated that Christiansen Lake fish were more robust. In Short Pine Lake there was no significant correlation of data between the two strains one year after the initial stocking; mean lengths and weights two years after stocking are not completely different. Based on accumulated results, an evaluation of which strain is more acceptable cannot be determined.

Only 0.6% of the original stocking of Naknek rainbow trout strains was captured in Tigger Lake. This low capture rate of Naknek fish follows the capture patterns of Winthrop-Ennis fish in other low productivity waters such as Marion and Christiansen lakes. These results may also be due to the presence of threespine stickleback.

The Reed Lake study is probably the most comprehensive as it involves evaluation of survival, growth, availability of the fish population to fishermen, and the effect of fin removal on Talarik and Swanson rainbow trout strains. A Chi-square analysis indicated a significant difference in gill net catches of marked Swanson-Talarik rainbows and unmarked rainbows. More marked Swanson rainbow were captured than expected and captured unmarked Talarik rainbow exceeded the expected value. A higher catch of unmarked Talarik rainbow was expected due to regeneration of pelvic fins of the marked Talarik fish. This result corresponds with the lower than expected catch of marked Talarik fish, although the inverse was true of marked Swanson fish where more were caught than expected. To test the possible effect on data caused by fin regeneration, the catch in excess of the expected values was divided and distributed in appropriate proportions to categories of marked fish. Chi-square analysis showed no significant difference in catches between marked and unmarked fish. Comparing fish strain composition by percent for hook and line and gill net caught samples with percent composition by strain at time of stocking, indicates no difference of strain availability in either sampling method.

Analysis of length-weight data for fish samples from Reed and Long lakes indicates: no significant differences in mean fork length of marked Swanson and marked Talarik fish, no significant difference in mean fork length of marked Swanson and unmarked Talarik fish, a significant difference in mean weight of marked Swanson fish to marked and unmarked Talarik fish, and a significant difference in mean fork length, mean weight, and condition factor of marked Talarik and unmarked Talarik fish. Talarik fish were significantly heavier than Swanson fish, and Swanson fish were significantly heavier than Talarik in Long Lake. Under cooling pond culture conditions Swanson fish were also found to be significantly heavier than Talarik fish.

Long Lake stocking ratio was one to three in favor of unmarked Talarik fish; however, subsequent gill netting yielded a catch ratio of two to one in favor of marked Swanson fish. Subsequent winter sampling yielded an insufficient sample size, consequently future analysis of the catch ratio will follow in spring, 1976.

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